**OFFICE OF RIVER PROTECTION**
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JAN 31 2014

14-TF-0003

The Honorable Peter S. Winokur
Chairman, Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Mr. Chairman:

TRANSMITTAL OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 2012-2 IMPLEMENTATION PLAN DELIVERABLE FOR ACTION 2-1 AND DISCUSSION OF THE DELIVERABLE FOR ACTION 4-2

This letter provides the deliverable responsive to the Action 2-1 Deliverable of the U.S. Department of Energy (DOE) Implementation Plan for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2012-2, Hanford Tank Farms Flammable Gas Safety Strategy. Action 2-1 is to install and test flow meters in selected double-shell tank (DST) ventilation exhausts to evaluate instrument performance.

Attachment 1 provides the report documenting the selection, installation, testing and evaluation for flow meters in selected (DST) ventilation exhausts. RPP-RPT-56041, *Tank Farm Projects DST Airflow Measurement Technology Recommendation Report*, documents the testing of thermal dispersion and differential pressure airflow measuring technologies in DSTs AZ-102 and SY-102. The report recommends that the thermal dispersion technology be implemented in the DSTs.

Attachment 2 provides the expected implementation schedule for installation of permanent Safety Significant real-time flow measurement in the DST tank farms. This schedule shows only three of the five DST farms being complete by the Action 2-2 Deliverable date of October 2015, with the last two farms following in December 2015 and March 2016. DOE notes that this installation does include acceleration of the implementation of wireless readout to a control room (whereas in early planning this was performed as a secondary step after the in-farm readout was achieved).

While the DOE, Office of River Protection (ORP) is evaluating opportunities for schedule acceleration, we are also working with DOE Environmental Management and Heath, Safety and Security personnel to prepare an Implementation Plan (IP) addendum to address the discrepancy between the most current schedule and the IP.

Due to fiscal year funding shortfalls based on the continuing resolution appropriation levels in 2013 and early 2014, some 2012-2 IP work has been delayed. With the recent omnibus bill appropriating the tank farms project at the requested President's level, 2012-2 IP work will see a significant ramp-up for the remainder of the fiscal year. At this time, there are not any foreseen anomalies that would deter additional funding shortfalls with this effort.

The next deliverable for the 2012-2 IP is for Action 4-2, "*Demonstrate current capabilities to recover from a loss of ventilation*," which has a commitment date of February 2014. This work is underway and DOE expects the deliverable report from the contractor at the end of February. Therefore to allow for the appropriate DOE review, comment and transmittal of the deliverable to the Board, ORP anticipates a March 2014 transmittal.

Kevin W. Smith
Manager

Attachments

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# ATTACHMENT 1

# 14-TF-0003

# RPP-RPT-56041: TANK FARM PRPJECTS DST AIRFLOW MEASUREMENT TECHNOLOGY RECOMMENDATION REPORT

RPP-RPT-56041, Rev. 1

# Tank Farm Projects DST Airflow Measurement Technology Recommendation Report

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U.S. Department of Energy Contract DE-AC27-08RV14800

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Key Words: Ventilation monitoring system, ventilation, monitoring, vent flow technology field evaluation, vent flow evaluation, KURZ™ thermal mass flow transmitter 454FTB, FURNESS CONTROLS FCO510 micromanometer, DNFSB Recommendation 2012-2, RPP-PLAN-55763, DST Vent Flow Instrument Technology Evaluation Whitepaper.

Abstract: This report provides a recommendation to DOE on an airflow measuring technology that addresses the requirements specified in letter WRPS-1302384 dated July 24, 2013 as part of Sub-recommendation 2012, Action 2-1.



DATE:
Dec 31, 2013
HANFORD RELEASE

APPROVED
By G.E. Bratton at 1:31 pm, Dec 31, 2013

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**Approved For Public Release**

# Tank Farm Projects DST Airflow Measurement Technology Recommendation Report

Juissepp S. Rodriguez
**WASHINGTON RIVER PROTECTION SOLUTIONS LLC**

Date Published
December 2013

Prepared By:

Washington River Protection Solutions LLC
Contractor for the U.S. Department of Energy
Contract No. DE-AC27-08RV14800

# EXECUTIVE SUMMARY

In September 2012, Defense Nuclear Facilities Safety Board (DNFSB) issued DNFSB Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, which included within it five recommendations (hereafter referred to as Sub-recommendations) and associated activities. In general, DNFSB Recommendation 2012-2 identified the need to take actions to reduce the potential risk posed by flammable gas events at the Hanford Tanks Farms.

This report supports Action 2-1 outlined within the Implementation Plan for DNFSB Recommendation 2012-2. Action 2-1 provides direction to "Install and test flow meters in selected Double Shell Tank (DST) ventilation exhaust systems to evaluate instrument performance."

This report outlines the thermal dispersion and differential pressure airflow measuring technologies, as well as the AZ-102 and SY-102 double-shell tank (DST) selection process. It also evaluates the performance of both technologies for an approximate 90 day period. The results of the evaluations showed that the thermal dispersion technology performed the best out of the two technologies that were selected.

Cumulatively, the results for the thermal dispersion technology showed to be more accurate and reliable throughout the evaluation period compared to the differential pressure technology.

Based on the information provided within this report, the recommended thermal dispersion technology will support the next Action Item under Sub-recommendation 2012-2. This will be covered at a later time in a separate report.

| Tank Operations Contractor (TOC)<br>**RECORD OF REVISION** | (1) Document Number:<br>RPP-RPT-56041 | | Page i |
|---|---|---|---|
| (2) Title:<br>Tank Farm Projects DST Airflow Measurement Technology Recommendation Report | | | |
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| RS 1 | Changes to the report were based on additional comments that need to be incorporated for better clarification. | Juissepp S. Rodriguez (12-27-13) [signature] | Jeremy J. Whitcomb (12-27-13) [signature] |

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# TABLE

# ACRONYMS

| | |
|---|---|
| ANSI | American National Standards Institue |
| ASHRAE | American Society of Heating, Refrigeration, and Air-Conditioning Engineers |
| DNFSB | Defense Nuclear Facilities Safety Board |
| DOE | U.S. Department of Energy |
| DSA | documented safety analysis |
| DST | double-shell tank |
| ECN | Engineering Change Notice |
| FCI | Fluid Components International |
| FTP | flow test ports |
| GS | general service |
| HCA | Highl-Contamination Area |
| IH | Industrial Hygiene |
| ISA | International Society of Automation |
| ISC | Ignition Source Control |
| LCD | Liquid Crystal Display |
| LFL | lower flammability limit |
| OSHA | Occupational Safety and Health Administration |
| PNNL | Pacific Northwest National Laboratory |
| RADCON | Radiological Control |
| SAC | Specific Adminstrative Control |
| SIL | safety integrity level |
| SIS | safety instrumented system |
| SME | subject matter expert |
| SOE | Stationary Operating Engineer |
| SS | safety significant |
| TSR | technical safety requirements |
| WRPS | Washington River Protection Solutions |

# 1.0 BACKGROUND

The function of the five primary ventilation systems servicing the 28 double-shell tanks (DST) at the Hanford Tank Farms is to remove flammable gases that may be generated by the tank waste due to radiolysis, thermolysis, and corrosion. The DST primary ventilation systems maintain the concentration of flammable gases in the DST headspace (resulting from steady-state and induced gas releases due to water additions, chemical additions, and waste transfers into DSTs) below the lower flammability limit (LFL).

In 2012, U.S. Department of Energy (DOE) detailed to the Defense Nuclear Facilities Safety Board (DNFSB) near-term plans for DST ventilation system upgrades in Fiscal Years 2013 and 2014. This included compensatory measures in place and planned upgrades to safeguard the operability of the DST primary ventilation systems to ensure that flammable gases cannot accumulate to hazardous levels. However, DNFSB considered that the specific administrative control (SAC) for flammable gas control was inadequate. DNFSB Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, was then approved by DNFSB.

The DOE response to DNFSB Recommendation 2012-2 identifies the need to take actions to reduce the risk posed by flammable gas events at the Hanford Tank Farms and included five Sub-recommendations with Action items. Within the Sub-recommendations, it included Sub-Recommendation 2, Action 2-1: Install and test flow meters in selected DST ventilation exhausts to evaluate instrument performance.

This document outlines the activities to address Sub-recommendation 2012-2, Action 2-1. This includes the selection, procurement, field performance, evaluation, and recommendation of an airflow measuring technology. The recommended technology will support the next Action item under Sub-Recommendation 2012-2: Install safety-significant (SS) instrumentation for real-time monitoring of the ventilation exhaust flow from each DST. This will be covered at a later time in a separate report.

# 2.0 PURPOSE

The purpose of this report is for Washington River Protection Solutions (WRPS) to make a recommendation to DOE on an airflow measuring technology that addresses the requirements specified in letter WRPS-1302384 dated July 24, 2013 as part of Sub-recommendation 2012-2, Action 2-1. The recommendation is based on a field evaluation and performance period of approximately 90 days for the two different types of airflow measuring technologies selected.

Future activities will consist of the selection of an airflow instrument from the recommended technology, design, procurement, and permanent installation of the selected airflow instrumentation as SS within the DSTs. These future activities will address the requirements set forth in the Implementation Plan for DNFSB Sub-recommendation 2012-2, Action 2-2.

Currently, as an interim measure, WRPS is required to take manual airflow readings from each individual DST exhaust flow test ports (FTP) annually, or immediately after repositioning a DST tank outlet isolation valve or a flow control valve.

# 3.0 REQUIREMENTS

Prior to installing permanent SS equipment in the field, airflow measuring technologies are required to be evaluated under representative conditions for tank waste storage. The following requirements were used in the selection process for airflow measuring technologies and DST test locations:

- Select location and establish criteria on two representative tank vent systems to install the selected airflow measuring instruments.
- Insure instrument has capability to operate within the flammable gas environment.
- Select airflow measuring instrument models for each of the selected airflow measuring technologies to measure airflow within prescribed limits during the field evaluation.
- Evaluate the operability and maintainability of airflow measuring technologies.

# 4.0 SELECTION PROCESS

This section covers how the DSTs (AZ-102 and SY-102) and the airflow measurement technologies (thermal dispersion and differential pressure) were selected for further evaluation.

## 4.1 TANK SELECTION

An evaluation of DSTs to find the most appropriate tank farm to establish initial parameters was first conducted via a farm-by-farm comparison. Then, a review was conducted to determine the optimal tank in the two most appropriate tank farms. This evaluation was conducted using a multi-attribute decision-making methodology that assigned measures, definitions, and weighting factors for each of the selected evaluation criteria (see Table 1 for further detail). Each measure was given a rating which was then used to score both the tank farms and the DSTs. The results for the selected DSTs can be found in Appendix A, Tables A-1 and A-2.

Prior to selection of the airflow instruments, tanks AZ-102 and SY-102, shown in Figures 1 and 2, were chosen to establish the initial parameters in which the selected airflow measuring instruments for each technology would be evaluated. They also provided a harsh environment such as high airflows with heat components (high degree of solids and moisture) throughout the evaluation period.

Results in Appendix A, Table A-2, show that DST SY-103, part of Group A Tank, scored the same as SY-102 in all areas except for the higher waste temperature in SY-103. Due to the project logistics, it was decided to select the SY-102 tank for the ease of installation. Equipment in DST Group A tanks primary ventilation ducting is required to comply with Ignition Source Control (ISC) Set 2 requirements as identified in TFC-ENG-STD-13, *Ignition Source Control Evaluation*. As stated in the TOC-ENG-FGEAB-00011, *FGEAB Report, Kurz Mass-flow Transmitter Use in AZ-102 AND SY-102 Ventilation Ducts*, the KURZ™ Mass-Flow Transmitter 454FTB meets ISC Set 2 requirements as well as National Fire Protection Administration (NFPA) 70, Class I, Division II, and Groups ABCD requirements.

The results between all of the AY/AZ DSTs scored equally. With the help of a panel of experts, it was agreed that the AZ DSTs were exposed to a high degree of solids and moisture, as well as chemical components, when compared to the AY DSTs. Following the acceptance to proceed forward with the AZ DSTs, DST AZ-102 was chosen for the evaluation due to DST AZ-101 having a Highly Contaminated Area (HCA) where the evaluation would have taken place.

**Table 1.** Decision Measures for DST Selection

| Criterion | Measure | Definition |
|---|---|---|
| Safety | Minimizes Hazards | 5 = Few, if any, hazards |
| | | 3 = Moderate hazards |
| | | 1 = Significant or new |
| | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, RADCON, IH) | 5 = Risk to worker occupational safety LOW |
| | | 3 = Risk to worker occupational safety MEDIUM |
| | | 1 = Risk to worker occupational safety HIGH |
| Tank Behavior | Avg. Tank Airflow Rate [cfm] | 5 = ≤60 [cfm] |
| | | 3 = ≥200 [cfm] |
| | | 1 =61-199 [cfm] |
| | Temperature | 5 = ≥ 120°F |
| | | 3 = 80-119°F |
| | | 1 = ≤79°F |
| Cost and schedule | Access to Tank Farm/Resources | 5 = Minimal (no pit access) |
| | | 3 = Moderate (recirculation module access) |
| | | 1 = Significant resources needed (pit access) |
| Impact on Project | Impact due to other activities taking place in Tank Farm | 5 = Minimal impact |
| | | 3 = Moderate impact, requiring minor modifications in Tank Farm activities |
| | | 1 = Significant impact, requiring major modifications in Tank Farm activities |

Note: Each measure is defined on a scale of 1 to 3 or 1 to 5, where the highest numeric value is considered the best depending on the criteria's definition.

**Figure 1. AY/AZ Tank Farm.**

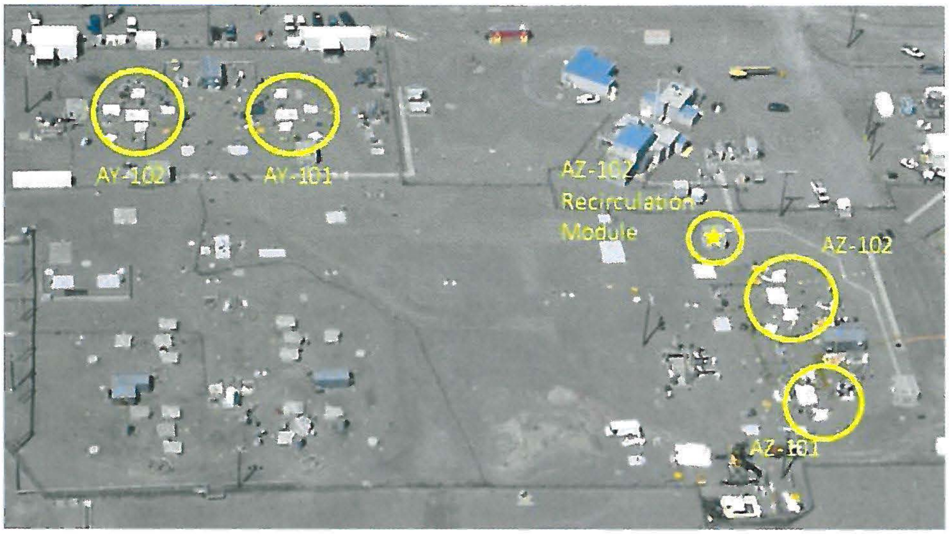



Figure 1 shows the location of the selected DST (AZ-102) in the AY/AZ Tank Farm. The star (★) represents the location of where the selected airflow measuring instruments were installed. See Section 4.2 for further information on the selected airflow measuring instruments.

**Figure 2. SY Tank Farm.**

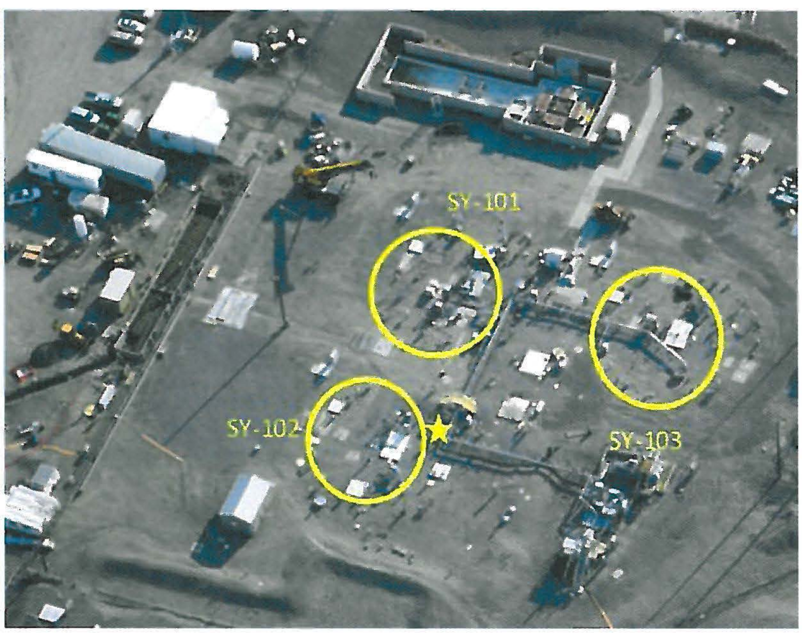



Figure 2 shows the location of the selected DST (SY-102) in the SY Tank Farm. The star (★) represents the location of where the selected airflow measuring instruments were installed. See Section 4.2 for further information on the selected airflow measuring instruments.

## 4.2 INSTRUMENT TECHNOLOGY SELECTION

The parameters (i.e., airflow rate, temperature, pressure) from the selected DSTs were used to initiate the airflow measuring instruments selection process. A total of six different types of commercially available technologies were initially selected for further technical evaluation against the selected DST exhaust parameters. These technologies are detailed in Appendix A, Table A-3, as well as Appendix C. The selection of these technologies were based on, but not limited to: existing instruments within the DOE complex (Hanford and Savannah River), researching various manufacturers, and technical discussions with experts at Pacific Northwest National Laboratory (PNNL), WRPS, and from the DOE Savannah River Site.

Based on available documentation and discussions with the subject matter experts (SME), it was determined that two of the six possible technologies aligned with the required measurement conditions and parameters. These technologies were identified as the thermal dispersion and differential pressure. Notable features of both selected technologies included the ability to measure airflow in the low velocity range and ease of installation, including compatibility with the existing flow test ports (FTP). The scoring of these two technologies is further detailed in Appendix A, Table A-4.

Specific make and model of the instruments were identified for field evaluation from within the above two technologies. Each instrument's feasibility was evaluated using a method similar to the one used to determine the preferred DSTs (see Table 2 below for further detail). Once the instruments were evaluated and scored, the selected airflow meter instruments were chosen based on the instruments' score. The two instruments that scored the highest were the KURZ™ 454FTB thermal mass flow transmitter for the thermal dispersion technology and the Furness Controls FCO510 micromanometer for the differential pressure technology.

**Table 2.** Decision Measures for Instrumentation Selection

| Criterion | Measure | Definition[1] |
|---|---|---|
| Safety | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, RADCON, IH) for Non-Incendive and explosion-proof/flame-proof | 5 = Risk to worker occupational safety LOW |
| | | 3 = Risk to worker occupational safety MEDIUM |
| | | 1 = Risk to worker occupational safety HIGH |
| Measurements | Avg. Tank Airflow Rate [cfm][3] | 5 = Capable of reading both chosen tanks (0-500 [cfm]) |
| | | 3 = Capable of reading one out of the two chosen tanks ( 0-500 [cfm]) |
| | | 1 = Not capable of reading neither of the two chosen tanks within 0-500 [cfm] |
| | Accuracy[4] | 5 = ±1% accuracy |
| | | 3 = ±2% accuracy |
| | | 1 = ≥ ±3% accuracy |
| Resources | Installation of equipment | 3 = Minimal |
| | | 1 = Moderate (Taking out current instrumentation to place new/modified instrumentation for installation) |
| Operability & Maintainability | New/familiar/current | 5 = Currently/similar used instrumentation |
| | | 3 = Similar instrumentation used at Hanford facility |
| | | 1 =New instrumentation technology to Hanford facility |
| Cost and Schedule | Equipment cost[2] | 5 = <$3,000 |
| | | 3 = $3,000 – $4,000 |
| | | 1 = >$4,000 |
| | Equipment lead time[2] | 5 = 0-4 weeks |
| | | 3 = 5-6 weeks |
| | | 1 = >6 weeks |
| | Availability to be placed at a 45° angle from the center of the duct. | 3 = Yes |
| | | 1 = No |
| | Availability to use current vent flow ports[5] | 5 = Can fit in both 3/4" and 1" ports |
| | | 3 = Can only fit in 1" ports |
| | | 1 =Can't fit in neither a 3/4" and 1" ports |
| Impact on Project/ stakeholder acceptance | Equipment is available/can be upgraded to SS requirements to be accepted by DOE-ORP and is consistent with DNFSB Sub-recommendations (e.g., improve the robustness of flammable gas control in the near term [2012-2]) | 5 = Equipment can be readily upgraded to SS requirements |
| | | 3 = Minor modifications will be required to upgrade to SS |
| | | 1 = Major modifications will be required to upgrade to SS |

Note 1: Each measure is defined on a scale of 1 to 3 or 1 to 5, where the highest numeric value is considered the maximum possible score depending on the criteria's definition.

Note 2: While some of the factors were considered significant for the field evaluation (e.g. equipment cost and lead time), they may not be as much of a factor for the permanent installation.
Note 3: The average tank airflow rate's definitions are based on the airflow rates of the two DST that were chosen (SY-102 ≈ 450 [cfm] and AZ-102 ≈ 130 [cfm]). Some of the instruments under the differential pressure technology were not able to read AZ-102 airflow rates under the current conditions making them score lower than the rest of the airflow instruments.
Note 4: The accuracy definitions were chosen based on the high and low percent accuracy values of all the instruments (from the two selected technologies).
Note 5: The definition for the availability to use current vent flow ports are based on the DST where the airflow technologies were installed. Although all of the DST currently have vent flow ports, they vary in size. For example, SY-102 DST has a ¾" vent flow port entry whereas the AZ-102 DST has a 1" vent flow port entry.

The KURZ™ was selected as the preferred instrument under the thermal dispersion technology, along with the Fluid Components International (FCI) ST100. Cost was the deciding factor for choosing the KURZ™ over the FCI. The FCI was approximately twice the cost as the KURZ™ instrument. Another defining feature contributing to the selection of the KURZ™ instrument was the ability to measure and display air velocities in units down to single digits (e.g., cubic feet per minute [cfm]), as well as the ability to increase the temperature 100 °F above the environment temperature (for humidity purposes).

The Furness Controls FCO510 micromanometer was selected as the preferred instrument under the differential pressure technology. Although the micromanometer is a lab instrument and has very sensitive [cfm] readout, it is available and has been used many times at the Hanford Tank Farms. This instrument also has the ability to measure and display in units down to single digits. Another feature for this instrument is that it is the only differential pressure instrument that can be placed in the current 45° angle flow ports. The other differential pressure instruments, if placed at the current 45° angle flow ports, would either not work properly or would show a high percent error in the readouts.

# 5.0 FIELD PERFORMANCE AND TECHNICAL EVALUATION

The purpose of this section is to discuss the airflow data that was gathered over approximately 90 days during a temporary installation of the two selected airflow measuring technologies. The technologies were installed as GS into flow test ports (FTP) in the two DST outlet ventilation ducts. Once the selection of both the DSTs and technologies were completed, the technologies were then evaluated against evaluation criteria (see Section 5.2.1 Table 3 for further detail).

## 5.1 FIELD PERFORMANCE

Following the discussions of previous sections, construction of support hardware and installation of instrumentation were accomplished using standard work control processes for installation and post maintenance evaluation. The work packages for the AZ and SY farms contained instructions for installation, allowance for adjustment of instrumentation during the evaluation period, and included removal of the GS instrumentation and restoration of the plant to the original state after the 90 day data collection period.

The GS airflow measurement technologies were then installed in two existing, code compliant FTPs at each DST ventilation outlet ducts. These FTPs were originally installed to perform manual airflow measurement readings for all DST exhaust plenums annually, or when the DST configuration changes could potentially affect the airflow rates.

Prior to airflow instrument installation, manual airflow readings using a hand held differential pressure airflow measurement device were taken to serve as a baseline for comparison purposes. A final airflow reading after the 90 day data collection period was taken when the instruments were removed in order to verify the baseline. The hand held differential pressure airflow measuring device is maintained and controlled under the measuring and testing equipment program and is an approved instrument to measure current Technical Safety Requirements (TSR) as stated in RPP-13033, *Tank Farms Documented Safety Analysis* (DSA).

Data from the airflow measuring instruments were gathered for approximately 90 days, providing a statistical number of data points which helped evaluate the airflow measurement technologies' performance over the evaluation period. The data points from the airflow measuring instruments were captured in temporary rounds once a day for each airflow measurement technology by a Stationary Operating Engineer (SOE) via daily operation rounds. The SOE would fill out all the information required in the temporary round sheets, including any abnormal conditions or system configurations that may affect the readings. The gathered data points were evaluated against the initial manual readings taken before the instruments were installed, against the final manual readings taken after the instruments were removed from the system, anomalies and trends, and against changes in ventilation system configurations or operations.

Throughout the evaluation, data was reviewed to allow for adjustments. This included comparing it to climatological data to identify any correlations, changes in data, and any noticeable trends. Modifications to the instruments' installation, settings (i.e., re-calibrate to an average signal), and/or correction of issues (i.e., loss of power) were made to better meet the overall objectives of providing a basis for instrument selection and were performed as follows:

- AZ-102
  - Problems in obtaining data points became an issue due to the distance and location of the thermal dispersion technology. A small camera was set up in front of the thermal dispersion technology data display screen that provided a better visualization of the values on a monitor that was set up on a table next to both instruments.
  - Both instruments required the installation of an average function by adjusting signal settings. This setting programmed the instruments so that every 20 seconds it would average the data points it obtained. By applying the average function signal to both technologies (installed on 8/21/13), it aided operators in obtaining data point values.
- SY-102
  - Due to the location of the differential pressure technology installation, extra tubing needed to be routed from the differential pressure instrument to its local readout.

- Loss of power on both instruments became a problem due to extension cord issues on the thermal dispersion technology. Both technologies' pigtails were too bulky as originally installed making both instruments hard to plug in the receptacle. A new extension cord with different pigtail was used for the thermal dispersion technology, and was plugged into a different receptacle to avoid any further power loss.
- While installation of the average function settings was going to be installed for the technologies, problems due to timing around the farm power and ventilation outages, prevented us from doing so.

After the 90 day data gathering period, the instruments were removed and the ventilation systems returned to their pre-evaluation condition. The data gathered was evaluated in Section 5.2 and the results are explained in further detail under Section 6.0. During the removal of the instruments, the condition of the instruments were observed for any instrument fouling or build up that could address any data anomalies encountered through the evaluation period. No fouling or build up was observed on any equipment.

## 5.2 TECHNICAL EVALUATION

This section explains the process, criteria, goals, and supporting data that were used for the evaluation. The evaluation was based on the requirements that were addressed in Section 3.0.

### 5.2.1 Evaluation Criteria

The screening criteria used to evaluate the airflow measurement technologies in Table 3, used both a quantitative and qualitative method, similar to the one used to determine the preferred DSTs and the airflow measurement instrumentations. Once the instruments were evaluated and scored, a recommendation on the selected technology was made and is further detailed under Section 6.0.

**Table 3.** Technology Selection Decision Criteria

| Criterion | Measure | Definition |
|---|---|---|
| Safety | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, RADCON, IH) for Non-Incendive and explosion-proof/flame-proof | 5 = Risk to worker occupational safety LOW<br>3 = Risk to worker occupational safety MEDIUM<br>1 = Risk to worker occupational safety HIGH |
| Measurements | Technology is able to meet and read the avg. tank airflow rates (cfm) in our current Hanford vent flow ports as required in our DSA (i.e. less than 40 [cfm]) | 5 = ≥ 50% of the selected technology are capable of reading < 40 [cfm][6]<br>1 = < 50% of the selected technology are not capable of reading < 40 [cfm][6] |
| | Outliers | 5 = No outlier data points<br>3 = 1-3 data point outliers<br>1 = 4 or more data point outliers |

**Table 3.** Technology Selection Decision Criteria

| Criterion | Measure | Definition |
|---|---|---|
| | Within the baseline values/error bars | 5 = ≥ 90% of data is within the error bars<br>3 = 71-89% of data is within the error bars<br>1 = ≤70% of data is within the error bars |
| | Easily readable data (e.g. steady readings) | 3 = Data is easy to read and obtain data point<br>1 = Data is not easy to read and can't obtain data point |
| | Good physical visibility for collecting data manually via LCD screens/projection screens are easily readable. | 3 = Data is easy to read and obtain data point<br>1 = Data is not easy to read and can't obtain data point |
| | Instrument adjustments are user friendly | 3 = User friendly<br>1 = Not user friendly |
| | Data output sensitivity due to outside source (e.g. wind, physical contact, rain, snow, etc.) | 5 = Not sensitive<br>3 = Somewhat sensitive<br>1 = Very sensitive |
| | Is remote output capabilities available for the instruments? | 3 = Yes<br>1 = No |
| Resources | Installation of equipment | 3 = Minimal<br>1 = Moderate |
| | Removal of equipment | 3 = Minimal<br>1 = Moderate |
| Operability & Maintainability | Instrument history at a DOE facility: new/familiar/current | 5 = Currently/similar used instrumentation<br>3 = Similar instrumentation used at DOE facility<br>1 = New instrumentation technology to DOE facility |
| Cost and schedule | General Service (GS) technology instrument cost | 5 = <$4,000<br>3 = $4,000 - $5,000<br>1 = >$5,000 |
| | Technology instrument lead time | 5 = 0-5 weeks<br>3 = 6-7 weeks<br>1 = >7weeks |
| | Calibration cost & effort | 3 = No calibration cost & effort is needed<br>1 = Calibrations cost and efforts are to be expected |
| | Availability to use current Hanford vent flow ports | 5 = Can fit in both 3/4" and 1" ports<br>3 = Can only fit in 3/4" or 1" ports<br>1 = Can't fit in neither a 3/4" and 1" ports |

**Table 3.** Technology Selection Decision Criteria

| Criterion | Measure | Definition |
|---|---|---|
| Impact on Project/ stakeholder acceptance | Instrument's Safety Integrity Level (SIL) can be rated and certified by a 3rd party | 5 = Instrument is SIL 2 rated<br>3 = Instrument is SIL 1 rated<br>1 = Instrument can't be SIL rated. |

Note 6: The 40 [cfm] identified, is the required [cfm] per DSA Section 4.4.10, System Evaluation, and Technical Specification Requirements, LCO 3.1 DST Primary Tank Ventilation Systems.

### 5.2.2 Scoring

Each measure shown in Table 3 is defined on a scale of either 1 to 3 or 1 to 5, where the highest numeric value is considered the maximum possible score depending on the criteria's definition. For example, the measure "Installation of equipment" is defined as being a "3" from a scale of 1 to 3 for the thermal dispersion technology if the anticipated installation is above grade. Conversely, this same measure would be rated as a "1" if the anticipated installation is below grade and a pit entry is required for the installation.
Appendix A, Table A-5, also describes the maximum values assigned to each criterion. These maximum values are assigned based on the best estimates as to their relative importance as evaluation process discriminators, not to their overall importance.

### 5.2.3 Data Results

The complete data results of both technologies are shown in Appendix B, with the AZ-102 results show in Figure B-1 and the SY-102 results shown in Figure B-2. Summary data result tables per DST are shown below in Tables 4, and are further explained in this section.

**Table 4. Data Points Outside the Average Error Bars**

| Technology | DST AZ-102 | DST SY-102 |
|---|---|---|
| Differential Pressure | 81 | 49 |
| Thermal Dispersion | 2 | 33 |

As mentioned earlier in the document under Section 5.1, manual airflow readings using a hand held device were taken prior to airflow instrument installation. These readings served as a baseline after the 90 day data gathering evaluation period to verify the baseline for comparison purposes. A +/-10% error was given to the averaged baseline value to set data point high and low error boundary. The +/- 10% was provided by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 111-2008, *Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems*, where it states that if there is normal airflow in the duct, the prescribed multi-point manual measurement would be within 10% of the actual airflow. Prior to the installation of the instruments, high and low error bars were obtained based on the average of both instruments' baseline data points, which were obtained using a hand held differential pressure airflow measurement device. The average high and low error bars help to clearly identify what data points are within acceptable/not acceptable limits, outliers, and any other anomalies that the project may encounter.

The same approach was performed after the 90 day evaluation period was completed to get another set of high and low error bars' boundary. The average of both error bars boundary for prior to and after the 90 day evaluation period was performed to come up with a final average data boundary points. The +/- 10% error used for the average data boundaries falls within the one sigma accuracy. Any data point within the one sigma accuracy is considered as meeting the expectations/true values. Any data point outside the one sigma accuracy would be looked at in further detail to see if it was truly an erroneous value or if there were any anomalies that could further attribute to an erroneous value (i.e., wind, rain, pressure, farm outages). The values that were considered outliers were determined to be values outside the two and a half sigma boundary. These outliers were discarded and removed from Table 4 as they indicated faulty data. Only DST AZ-102 had outliers; five for the differential pressure and one for the thermal dispersion technology. Factors that could have contributed to the outliers and data points observed outside the error bars are further discussed at the end of this section.

In the AZ-102 DST, a total of 87 days' worth of data points were obtained for the thermal dispersion technology compared to the 91 days' worth of data points obtained from the differential pressure technology. The reason behind this inconsistency was that several of the values provided by the thermal dispersion technology could not be taken due to its physical location. Due to this, a camera was installed with a monitor to provide better visualizations of the values. This was the only operating problem encountered in the AZ-102 DST.

In the SY-102 DST, a total of 66 days' worth of data points were obtained for the differential pressure technology and 44 days' worth of data points were obtained for the thermal dispersion technology. The following is a summary of problems that caused the instrument to lose days of data points.

Thermal Dispersion Technology:

- At the beginning of the evaluation period, trouble with the installation of the power cord caused the thermal dispersion technology to lose power and 14 days' worth of data points.

- Due to the inability to acquire enough work force resources to restore power to the instrument, it caused a loss of 15 days' worth of data points.

- The inability to access the tank farm due to the exhauster being shut down and the operator not being able to go in the farm and obtain readings caused a loss of 3 days' worth of data points.

- A tank farm power outage caused a loss of 19 days' worth of data points.

Differential Pressure Technology:

- The instrument powered off and caused a loss of 7 days' worth of data points.
- The inability to access the tank farm due to the exhauster being shut down and the operator not being able to go to the farm and obtain readings caused a loss of 3 days' worth of data points.
- A tank farm power outage caused a loss of 19 days' worth of data points.

Cumulatively, based on the results from Appendix B, Figures B-1 and B-2, the thermal dispersion technology showed it met expectations by having more data points fall within the one sigma accuracy boundary.

Some factors that could have contributed the outliers and data points observed outside the error bars could be from the following.

- The airflow inside the DST ventilation exhaust pipes experienced velocity fluctuations at point in turbulent flow due to the system configuration and flow test port locations. Turbulent flows are generally turbulent, involving random perturbations or fluctuations of the flow (velocity and pressure).
- For the differential pressure technology, radical changes to the data point values due to sensitivity of instrument. This could have been caused by wind, rain, pipe vibrations, etc.

The averaging signal setting modifications on the AZ-102 DST showed no difference between the pre- and post-modification that took place. This may indicate that higher increments of average trending airflow need to be identified at a later time to comply with the DSA/TSR limits of operability requirements. This will also reduce the need of relying on the operator's judgment or best guess by uploading and recording data points in a computer.

Data points were compared to climatological data. This comparison showed that climatological data had no correlation, nor showed any signs that climate changes affected any of the airflow measurement technologies data.

## 6.0 CONCLUSION AND RECOMMENDATION

In conclusion, six airflow measurement technologies were evaluated. Out of six technologies, the thermal dispersion and differential pressure technologies aligned with the required measurement conditions and parameters set in the criteria and weightings, as stated in Appendix A, Table A-5. Once the two technologies were field evaluated for an approximate 90 day period, the data points obtained, shown in Appendix B, were reviewed to conclude that accurate flow rates can be obtained by using the thermal dispersion technology.

Based on the information provided within this report, the recommended technology is the thermal dispersion technology. This selected technology addresses the requirements set forth in the Implementation Plan for DNFSB Sub-recommendation 2012-2, Action 2-1. This technology recommendation is based upon the results summarized within Appendix A, Table A-5.

## 7.0 REFERENCES

ANSI/ASHRAE 111-2008, *Testing Adjusting, and Balancing of Building HVAC Systems*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, Georgia.

ANSI/ISA-84.00.04, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*, American National Standards Institute/International Society of Automation, Research Triangle Park, North Carolina.

DNFSB Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, dated September 28, 2012.

DOE Response to Recommendation 2012-2, dated January 7, 2013.

DOE Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, dated June 6, 2013.

Letter, S .E. Bechtol, ORP, to C. A. Simpson, WRPS, *Contract No. DE-AC27-08RV14800 – Request for Proposal to Support the U.S. Department of Energy, Office of River Protection (ORP) Implementation Plan for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2012-2 Hanford Tank Farms Flammable Gas Safety Strategy*, 13-TF-0059/1302384, dated July 24, 2013.

RPP-13033, 2013, *Tank Farms Documented Safety Analysis*, Rev. 5-A, Washington River Protection Solutions LLC, Richland, Washington.

TFC-ENG-STD-13, *Ignition Source Control Evaluation*, as amended Washington River Protection Solutions LLC, Richland, Washington.

TOC-ENG-FGEAB-00011, 2013, *FGEAB Report, Kurz Mass-flow Transmitter Use in AZ-102 AND SY-102 Ventilation Ducts*, Rev. 0, Washington River Protection Solutions LLC, Richland, Washington.

# APPENDIX A

## Tables

**Table A-1.** Evaluation Matrix for the DST Selection

| Criteria | Measures | AN1 | AN2 | AN3 | AN4 | AN5 | AN6 | AN7 | AP1 | AP2 | AP3 | AP4 | AP5 | AP6 | AP7 | AP8 | AW1 | AW2 | AW3 | AW4 | AW5 | AW6 | AY1 | AY2 | AZ1 | AZ2 | SY1 | SY2 | SY3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Safety | Minimizes Hazards | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, Rad Con, IH) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| Tank Behavior | Avg. Tank Flow Rate [cfm] | 3 | 5 | 5 | 5 | 5 | 3 | 5 | 1 | 1 | 1 | 1 | 5 | 1 | 3 | 5 | 1 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 |
| | Temperature | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 5 | 5 | 1 | 1 | 3 |
| Cost and schedule | Access to Tank Farm Resources | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| Impact on Project | Impact due to other activities taking place in Tank Farm | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| | Scores for each Tank Farm | 1.86 | | | | | | | 1.25 | | | | | | | | 1.17 | | | | | | 3.00 | | | | 4.0 | | |
| | Top Two Tanks With Highest Scores from the Tank Farms with Highest Scores | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 18 | 18 | 18 | 18 | 22 | 24 | 26 |

**Table A-2.** Evaluation Matrix Selection for the AY/AZ and SY DSTs

| Criteria | Measures | AY1 | AY2 | AZ1 | AZ2 | SY1 | SY2 | SY3 |
|---|---|---|---|---|---|---|---|---|
| Safety | Minimizes Hazards | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, RADCON, IH) | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| Tank Behavior | Avg. Tank Airlow Rate [cfm] | 3 | 3 | 1 | 1 | 1 | 3 | 3 |
| | Temperature | 3 | 3 | 5 | 5 | 1 | 1 | 3 |
| Cost and schedule | Access to Tank Farm/Resources | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| Impact on Project | Impact due to other activities taking place in Tank Farm | 3 | 3 | 3 | 3 | 5 | 5 | 5 |
| | Total Points | 18 | 18 | 18 | 18 | 22 | 24 | 26 |
| | Final Tank Selection | – | – | – | 18 | – | 24 | – |

**Table A-3.** Evaluation Matrix for the Instrument Technology Selection

| Type of Airlow Meter | Company | Model | Comments |
|---|---|---|---|
| Thermal Dispersion | Enderss + Hauser, Inc. | Proline t-mass B150 | Instrument cannot read down to 45 [cfm] |
| | Fluid Components International LLC | ST100 | Instrument meets requirements |
| | Enderss + Hauser, Inc. | Proline t-mass 65I | Instrument cannot read down to 45 [cfm] |
| | ***KURZ™*** | Thermal Mass Flow Transmitter_454ftb | Instrument meets requirements |
| | Eldrige Products | Master-Touch Thermal Gas Mass Flowmeters Series 500 and 540 | Instrument cannot be evaluated due to not getting any feedback from vendors. |
| Vortex | Pro-V Multivariable Flowmeter | M23 Insertion Vortex | Only comes 2" and greater |
| | EMERSON Process Management | Rosemount 8800D Vortex Flowmeter | Will require flange installation |
| | RACIN | RNG Series | Will only work in 12" and greater size pipes and the instrument's probe only comes 2" wide. |
| | GE Panametrics | PanaFlow MV82 | Only comes 2" and greater |
| Ventury/orifice | – | – | Will require flange installation |
| Differential Pressure | EMERSON Process Management | Rosemount Annubar Series 3051SFA | Instrument cannot read down to 45 [cfm] |
| | Preso | AR Ellipse Annubar Flow Meter | Instrument cannot read down to 45 [cfm] |
| | Veris | Verabar | Instrument cannot read down to 45 [cfm] |
| | Furness Controls | ***FC0510 Micromanometer*** | Instrument meets requirements |
| | Air Monitor Corporation | Pitot Airflow Traverse Probe/MASS-TronII Transmitter | Instrument cannot read down to 45 [cfm] |
| V-cone | McCrometer | – | Inability to Operate in low pressure applications and is a flanged type |
| Magnetic | OMEGAMAG | FMG3000 | Design for liquid only operations |

| |
|---|
| ***Selected Technology*** |
| Does not meet our Needs |

**Table A-4.** Evaluation Matrix for the Instrument Selection

| Criteria | Measures | Thermal Dispersion Technology Instrumentation | | | | Pitot Tube Technology Instrumentation | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Proline t-mass 65I | ST100 | Proline t-mass B150 | Thermal Mass Flow Transmitter 454FTB | Air Monitor MASS-TronII with VOLU-probe/SS | FC0510 Micromanometer | Rosemount Annubar Flowmeter Series 3051SFA | AR Ellipse Annular Flow Meter |
| Safety | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, Rad Con, IH) for Non-Incendive and explosion-proof/flame-proof | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 |
| Reading | Avg. Tank Flow Rate [cfm] | 5 | 5 | 5 | 5 | 1 | 5 | 3 | 1 |
| | Accuracy | 5 | 5 | 1 | 3 | 1 | 5 | 5 | 5 |
| Resources | Installation of equipment | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 |
| Operability and maintainability | New/familiar/current | 3 | 3 | 3 | 3 | 5 | 5 | 3 | 3 |
| Cost and schedule | Equipment cost | 3 | 1 | 5 | 5 | 5 | 1 | 1 | 5 |
| | Equipment lead time | 1 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |
| | Availability to be placed at a 45° angle from the center of the duct. | 3 | 3 | 3 | 3 | 1 | 3 | 1 | 1 |
| | Availability to use current vent flow ports | 3 | 5 | 5 | 5 | 1 | 5 | 5 | 3 |
| Impact on Project/ stakeholder acceptance | Equipment is available/can be upgraded to SS requirements to be accepted by DOE-ORP and is consistent with DNFSB recommendations (e.g., improve the robustness of flammable gas control sin the near term [2012-2]) | 1 | 5 | 1 | 5 | 3 | 1 | 1 | 1 |
| | Total Points: | 32 | 38 | 32 | 38 | 24 | 34 | 30 | 30 |

**Table A-5.** Technology Selection Matrix Criteria, Measures, and Weightings

| Criterion | Measure | Maximum Value | Thermal Dispersion | Differential Pressure |
|---|---|---|---|---|
| Safety | Minimize risk to worker occupational safety for operations, maintenance and construction activities (OSHA, RADCON, IH) for Non-Incendive and explosion-proof/flame-proof | 5 | 5 | 5 |
| Measurements | Technology is able to meet and read the avg. tank airflow rates [cfm] in our current Hanford vent flow ports as required in our DSA | 5 | 5 | 5 |
| | Outliers | 5 | 5 | 1 |
| | Within the baseline values/error bars | 5 | 3 | 1 |
| | Easily readable data (e.g. steady readings) | 3 | 3 | 1 |
| | Good physical visibility for collecting data manually via LCD screens/projection screens are easily readable, | 3 | 3 | 3 |
| | Instrument adjustments are user friendly (e.g. damping function) | 3 | 3 | 3 |
| | Data output sensitivity due to outside source (e.g. wind, physical contact, rain, snow, etc.) | 5 | 5 | 1 |
| | Remote output capabilities available for the instruments | 3 | 3 | 3 |
| Resources | Installation of equipment | 3 | 3 | 1 |
| | Removal of equipment | 3 | 3 | 1 |
| Operability & maintainability | Instrument history at a DOE facility: new/familiar/current | 5 | 3 | 5 |
| Cost and schedule | General Service (GS) technology instrument cost | 5 | 5 | 1 |
| | Technology instrument lead time | 5 | 1 | 5 |
| | Calibration cost & effort | 3 | 3 | 1 |
| | Availability to use current Hanford vent flow ports | 5 | 5 | 1 |
| Impact on Project/ stakeholder acceptance | Instrument's Safety Integrity Level (SIL) is rated and certified by a 3rd party | 5 | 3 | 1 |
| **Total pts.** | | | **62** | **39** |

DNFSB = Defense Nuclear Facilities Safety Board.

SS = Safety Significant.

# APPENDIX B

## Figures

**Figure B-1. AZ-102 Data Results**

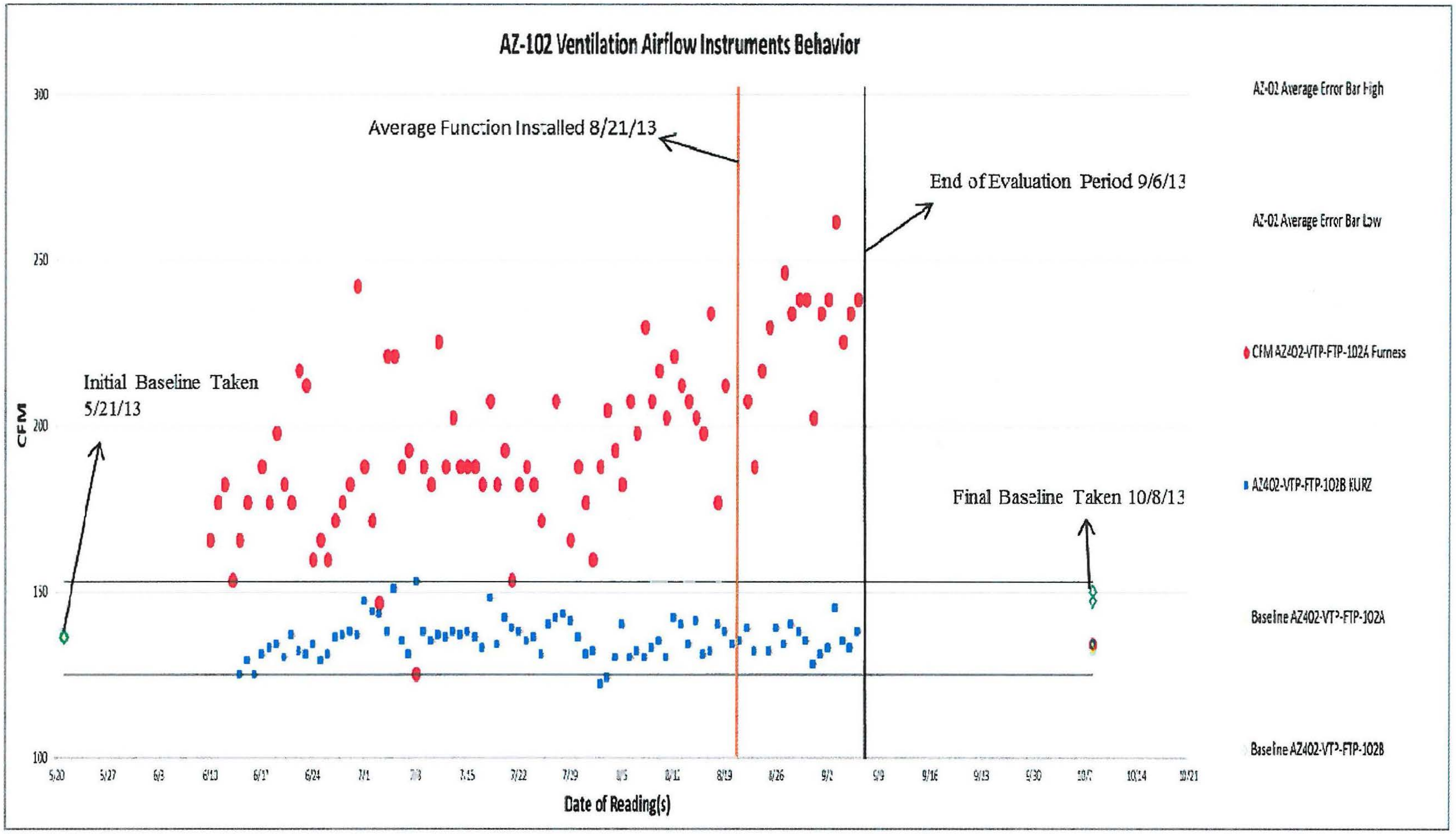
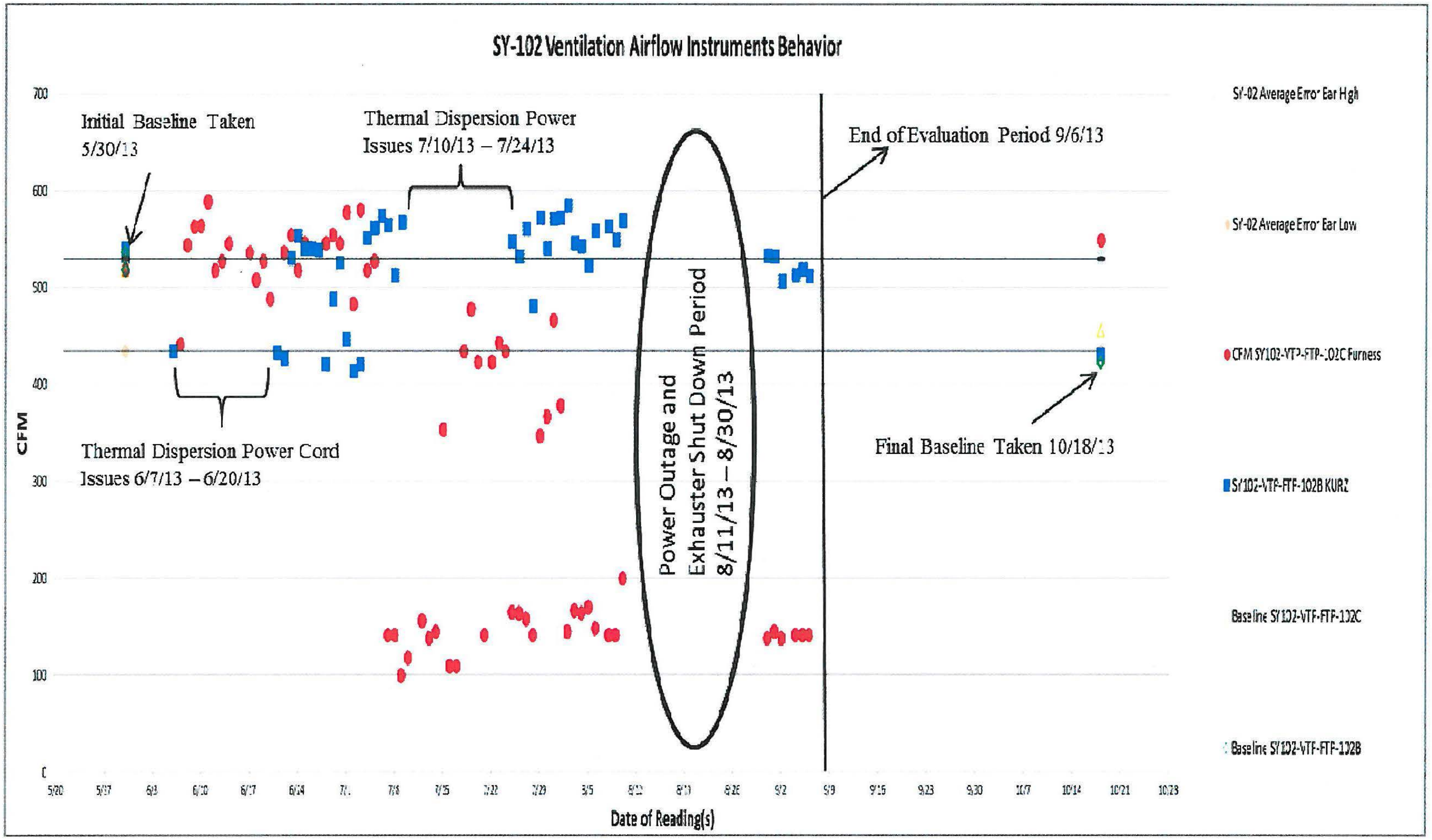


**Figure B-2. SY-102 Data Results**



# APPENDIX C

## Alternative Instruments/Technologies Considered

## C.1 THERMAL DISPERSION

### C.1.1 Proline T-mass

Two different types of Proline t-mass, the Proline t-mass 65I and the Enderss + Hauser, Inc. B150, were evaluated. These two instruments were deemed not acceptable for the following reasons:

- They do not have the ability to measure the low airflow rate that is required.
- The instruments would require an extended lead time of 13 to 18 weeks, compared to the other thermal dispersion instruments that range from 5 to8 weeks.

### C.1.2 FCI ST100

The FCI ST100 met all of the requirements required for selection. However, cost was the deciding factor in choosing the KURZ™ 454FTB instrument over the FCI ST100. The FCI ST100 ranged from approximately $7,000, while the KURZ™ 454FTB instrument was only $3,600.

### C.1.3 Differential Pressure

#### C.1.3.1 VOLU-Probe

The VOLU-Probe is an existing stainless steel differential pressure airflow instrument, coupled with an Air Monitor MASS-TronII (Air Monitor Corp.) transmitter which is currently used in the AY/AZ DSTs. This airflow meter was originally procured and installed as SS, but was then re-classified as general service (GS) due to not meeting new requirements, such as American National Standards Institute (ANSI)/International Society of Automation (ISA)-84.00.01, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*. At times, this existing airflow instrument has been shown to produce unreliable airflow data, especially in winter temperatures. The presence of condensate in the airflow probe sensing lines has been identified as the likely cause. Manual purging is required in order to provide reliable data when fouled due to water droplets hitting the probe and filling the sensing lines. The air supply used to purge the existing sensing lines sometimes contains oil and water, which require maintenance on the air system to be performed prior to purging the instrument lines.

According to the Air Monitor Corp. representative, this instrument was deemed unacceptable for our purposes for the following reasons:

- It does not meet the standards which are currently necessary for operating SS equipment. If both the VOLU-Probe and MASS-TronII transmitter were to be used based on the needs of safety function requirements, the transmitter and probe would need to be qualified for use in a Safety Instrumented System (SIS) per WRPS procedures.

- It does not have a local readout and would require a transmitter to read data points.
- A purging system would be required to be functional in order to ensure a reliable airflow measurement if the instrument became fowled due to condensate.
- It will not have the ability to measure the low airflow rate that is required.

#### C.1.3.1 Annubar Flow Meters

Two different types of Annubar flow meters were evaluated. These were the Rosemount Annubar Flow Meter Series 3051 SFA by Emerson Process Management and the AR Ellipse Annubar Flow Meter by Preso. Both of these instruments were deemed not acceptable by the instruments' representatives due to the following:

- They will not have the ability to measure the low airflow rate that is required.
- The instruments would require the tube with the multiple sample ports to be laid out across the inside of the ducting, which would only allow one instrument to be installed instead of two as planned in our scope.

The difference between the selected differential pressure instrument (FCO510 micromanometer) and an Annubar flow meter is that the Annubar averages out the airflow velocity by taking multiple samples from the airflow stream and the FCO510 micromanometer need only take a single sample from the airflow stream.

### C.1.4 Vortex

Two different types of instruments were considered for the vortex: a vortex flow meter RNG series insertion-style gas flow meter by Racine and a Rosemount 8800D vortex flow meter by EMERSON Process Management.

#### C.1.4.1 Racine

The vortex meter made by Racine was discussed with a company representative and deemed unacceptable because of the following:

- The instrument will only work in 12-inch and greater size duct pipes (AZ-102 DST is an 8-inch size duct pipe).

- The instrument's probe only comes with a 2-inch wide diameter, which will not fit in current FTPs.

#### C.1.4.2 Rosemount 8800D

The Rosemount 8800D vortex airflow meter was considered based on vendor recommendation and was verified by a vendor that it would work based on process requirements. The vortex flow meter can also be found certified for use in a safety integrity level (SIL)-1 system and would meet project safety requirements. The meter is capable of producing a reliable velocity output and does not require a purge system for operation.

The disadvantage of the vortex flow meter is its loss of accuracy from the presence of water in the process and its minimum airflow limitations. When water droplets hit the shedding strut inside the vortex flow meter, noise may be added into the velocity measurement. Furthermore, in order to achieve the minimum project airflow requirements, downsizing to a smaller diameter exhaust pipe is required.

#### C.1.4.3 Verabar

A Veris Verabar was initially considered due to its low pressure airflow measurement capability. A Verabar can also be installed with very minimal straight run requirements and can be installed in the AZ-102 8-inch line. Additionally, a Verabar is capable of performing a high turn down ratio for airflow measurements. The disadvantage of the Verabar is its inability to produce reliable airflow measurements in non-homogeneous process conditions. The intended application was discussed with a Veris applications engineer and was deemed unacceptable because of the condensation and low velocity pressure at low airflow rates.

### C.1.5 Magnetic

The magnetic FMG3000 by OMEGAMAG was considered due to its low airflow measurement capabilities. The intended application was discussed with an OMEGAMAG engineer and was deemed unacceptable because the instrument is strictly for liquids.

### C.1.6 V-Cone

A McCrometer V-Cone was initially considered because of its ability to reliably measure airflow in wet gas systems, including compressed air with a large content of condensed water. It also has the capability of being installed with very minimal straight runs of pipe and it can be installed in the AZ-102 8-inch line. The disadvantage of a V-Cone is its inability to operate in low pressure applications. The intended application was discussed with a McCrometer applications engineer and was deemed unacceptable.

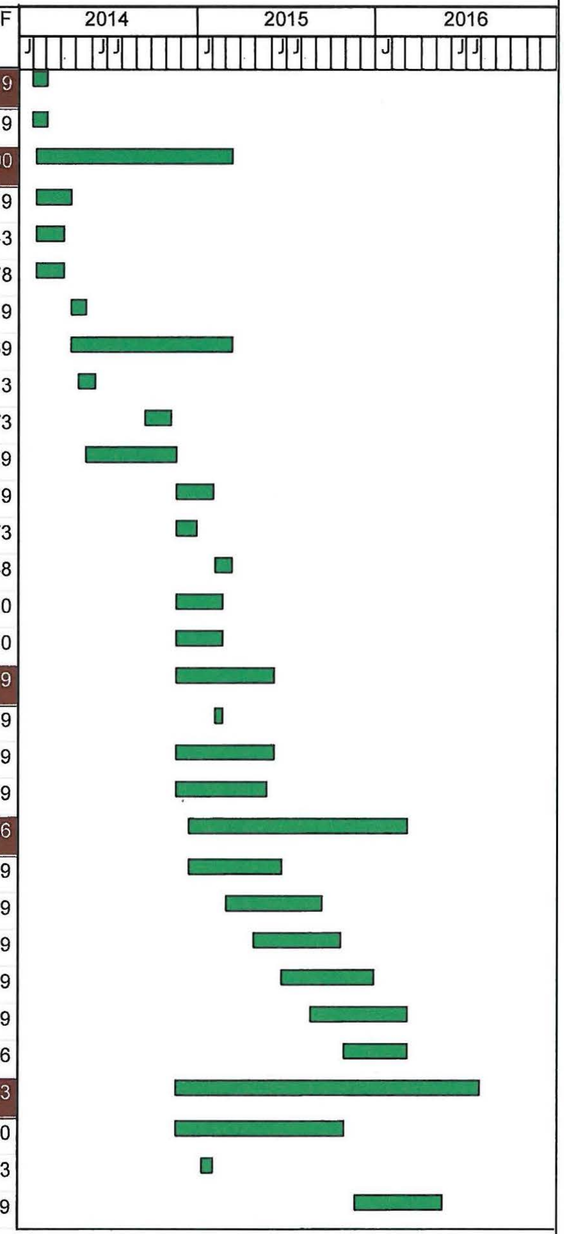
# ATTACHMENT 2

# 14-TF-0003

# DNFSB RECOMMENDATION 2012-2 PROPOSAL 2
# (ACTIONS 2-2, 2-3, 24)

# DNFSB Recommendation 2012-2 Proposal 2 (Actions 2-2, 2-3, 2-4)

| Line Number | Activity ID | Activity Name | RD | Forecast Start | Forecast Finish | TF |
|---|---|---|---|---|---|---|
| | | **Project Initiation** | 20 | 03-Feb-14 | 03-Mar-14 | -119 |
| | | Project Kickoff | 20 | 03-Feb-14 | 03-Mar-14 | -119 |
| | | **Design** | 276 | 10-Feb-14 | 16-Mar-15 | 190 |
| | | Safety Requirements Evaluation Document (SRED) - Initial Preparation | 50 | 10-Feb-14 | 21-Apr-14 | -119 |
| | | Hazards Analysis (Including SIL Level Selection) | 40 | 10-Feb-14 | 07-Apr-14 | -3 |
| | | Scoping Calc | 40 | 10-Feb-14 | 07-Apr-14 | -78 |
| | | Design Contract | 21 | 22-Apr-14 | 20-May-14 | -119 |
| | | Software Development | 225 | 22-Apr-14 | 13-Mar-15 | 59 |
| | | Safety Admin Software | 25 | 06-May-14 | 10-Jun-14 | -13 |
| | | Software Change Request (SCR) to TFMCS | 38 | 19-Sep-14 | 11-Nov-14 | 273 |
| | | Design - Instrumentation | 130 | 21-May-14 | 21-Nov-14 | -119 |
| | | SIL Verification Calculation | 50 | 24-Nov-14 | 06-Feb-15 | -79 |
| | | SRED Final Report | 25 | 24-Nov-14 | 02-Jan-15 | 173 |
| | | SIS Data Sheet | 25 | 09-Feb-15 | 16-Mar-15 | 148 |
| | | Mechanical Installation ECNs | 62 | 24-Nov-14 | 25-Feb-15 | 80 |
| | | Electrical Installation ECNs | 62 | 24-Nov-14 | 25-Feb-15 | 80 |
| | | **Procurement** | 136 | 24-Nov-14 | 10-Jun-15 | -119 |
| | | Plant Forces Work Review (PFWR) | 10 | 09-Feb-15 | 23-Feb-15 | -79 |
| | | Airflow Instrumentation | 136 | 24-Nov-14 | 10-Jun-15 | -119 |
| | | Installation Materials | 126 | 24-Nov-14 | 27-May-15 | -119 |
| | | **Construction** | 307 | 17-Dec-14 | 08-Mar-16 | -86 |
| | | SY Farm | 132 | 17-Dec-14 | 25-Jun-15 | -119 |
| | | AP Farm | 136 | 05-Mar-15 | 15-Sep-15 | -119 |
| | | AY/AZ Farm | 124 | 30-Apr-15 | 23-Oct-15 | -119 |
| | | AW Farm | 126 | 26-Jun-15 | 28-Dec-15 | -119 |
| | | AN Farm | 135 | 24-Aug-15 | 08-Mar-16 | -119 |
| | | Instrumentation Installation - DNFSB 2012-2 IP - Action 2-2 (Due Oct-15) | 86 | 30-Oct-15 | 08-Mar-16 | -86 |
| | | **Readiness/Testing/Turnover** | 424 | 24-Nov-14 | 01-Aug-16 | 43 |
| | | SBA Approval - DNFSB 2012-2 IP - Action 2-3 (Due Oct-15) | 235 | 24-Nov-14 | 30-Oct-15 | 0 |
| | | Test Plan Worksheet (TPW) | 20 | 12-Jan-15 | 06-Feb-15 | 83 |
| | | Testing | 120 | 24-Nov-15 | 17-May-16 | -119 |



# DNFSB Recommendation 2012-2 Proposal 2 (Actions 2-2, 2-3, 2-4)



| Line Number | Activity ID | Activity Name | RD | Forecast Start | Forecast Finish | TF |
|---|---|---|---|---|---|---|
| | | **Procedures** | 334 | 26-Jan-15 | 19-May-16 | -119 |
| | | **Training** | 15 | 13-May-16 | 03-Jun-16 | -119 |
| | | **Readiness** | 394 | 24-Nov-14 | 17-Jun-16 | -119 |
| | | **SBA Implementation - DNFSB 2012-2 IP - Action 2-4 (Due Dec-15)** | 119 | 30-Dec-15 | 17-Jun-16 | -119 |
| | | **Turnover** | 40 | 06-Jun-16 | 01-Aug-16 | 43 |